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THE ALTERATION OF HOST PLANT SPECIFICITY IN LARVAE OF PIERIS RAPAE BY INDUCTION[1]

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THE PURPOSE OF THE EXPERIMENTS described in this paper has been to illustrate how the larval selections of particular strains of *Pieris rapae* can change their preferences over a period of time according to the food plants on which they have been bred. It has already been shown that strains of this insect favor a plant on which the larvae have been bred, whether the exposure has been of short duration (less than one generation) or of long duration (over one generation).

The present experiments differ from those previously made in that the strains used are either deliberately confused as to preference (by hybridization or changing of food plants), or by selection for many generations on a different plant.

ORIGINS OF STRAINS OF PIERIS RAPAE

Four series of tests were made in the experiments; one series was bred on black mustard for several generations, one on kale, one on nasturtium and one was bred on *Isomeris*.

The black mustard strain was derived from hybrids between kale-and-mustard-strains as described before (Hovanitz and Chang 1963). They were confused as to food plants, both by hybridization and by breeding for six generations thereafter on a variety diet of mustard, nasturtium and *Isomeris* before the commencement of the tests described below.

The kale strain was derived from a strain grown on mustard for many generations.

The nasturtium strain and the *Isomeris strain* were both derived from a strain grown on kale for many generations. These original strains are described in a previous paper (Hovanitz and Chang 1964).

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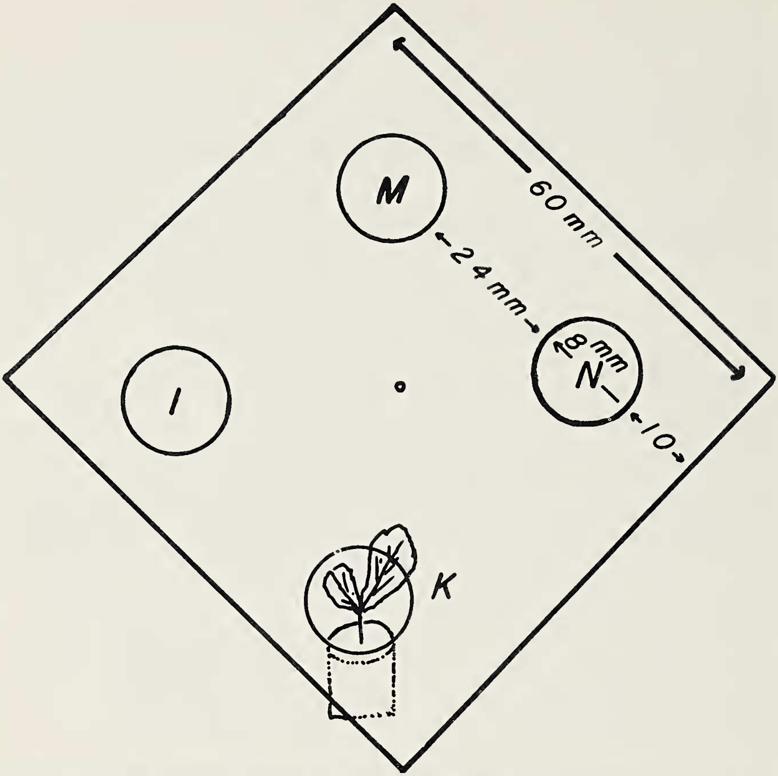

Fig. 1. Diagram showing the set-up of the selection experiments. M = mustard, I = Isomeris, N = nasturtuim and K = Kale.

PROCEDURE

The larvae used in these tests were raised exclusively on one of the following plants: black mustard, kale, nasturtium and *Isomeris* for the number of successive generations indicated in the description below.

The test procedures were the same as those described in the previous paper (Hovanitz and Chang, 1962). The setup, however, was changed slightly. Four different potted plants, about the same size (mustard, nasturtium, kale and *Isomeris*) were placed under a wooden platform, the leaves and the stems extending through the holes and above the surface of the platform as shown in fig. 1. In the test, generally more than ten middle sized larvae (14mm to 16mm in length) were placed in the central area shown by a small circle and allowed to go to the plants or to leave the platform. Each larva was tested 20 times.

THE SELECTED STRAINS

On black mustard: The first generation larvae of this strain had a nearly equal selection for mustard, kale and nasturtium (Table 1, Fig. 2) but little selection for *Isomeris*. The trend during eight generations of selection was up for mustard and down for nasturtium. For the first five generations, selection was down for kale and thereafter up. No obvious reason can be given for the latter result.

On kale: The first generation on kale (after having been on mustard for many generations) indicates highest selections on mustard (Table 2, Fig. 3). For over fourteen generations, selections decreased for mustard from 57 percent to 25 percent but increased for kale from 24 percent to 55 percent; this is a complete reversal of selections for these two plants. Selections for nasturtium and *Isomeris* did not change appreciably during this time.

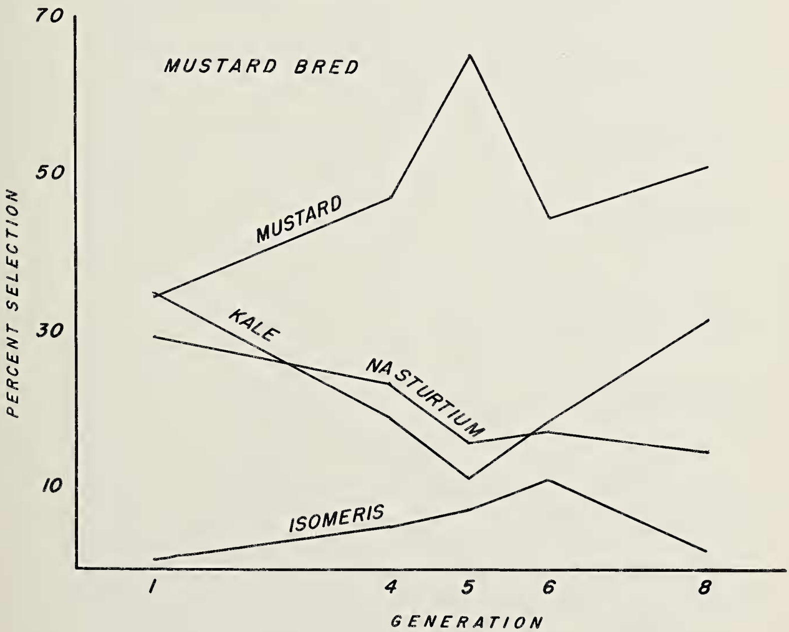

Fig. 2. Food plant selections by larvae of *P. rapae* fed black mustard.

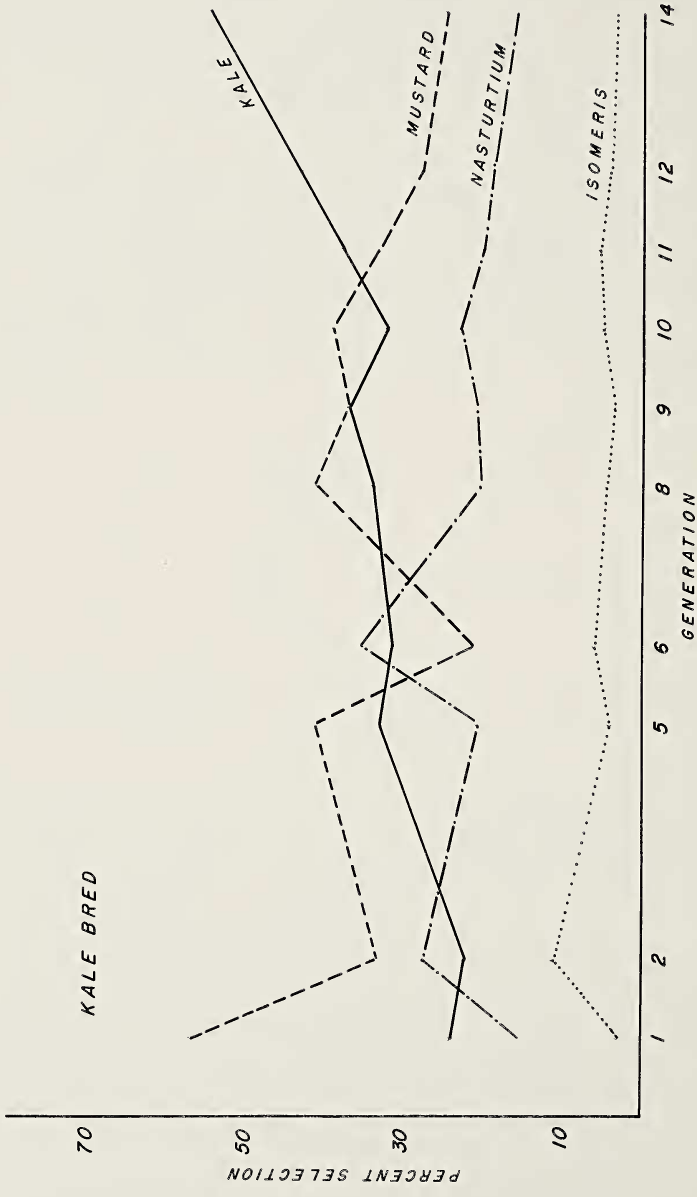

Fig. 3. Food plant selections by larvae of *P. rapae* fed kale.

Table 1. Food plant selections by larvae of Pieris rapae fed black mustard (Brassica nigra)

Generation	Mustard		Kale		Nasturtium		Isomeris		None		
	N	%	N	%	N	%	N	%	N	%	Total
1st	69	34.5	70	35.0	59	29.5	2	1.0	0	0	200
4th	226	47.1	95	19.8	113	23.5	26	5.4	20	4.2	480
5th	182	65.0	32	11.4	45	16.1	21	7.5	0	0	280
6th	133	44.3	56	18.7	52	17.3	34	11.3	25	8.3	300
8th	122	50.8	76	31.7	35	14.6	5	3.1	2	0.8	240

Table 2. Food plant selections by larvae of Pieris rapae fed kale (Brassica oleracea var. acephala)

Generation	Mustard		Kale		Nasturtium		Isomeris		None		Total
	N	%	N	%	N	%	N	%	N	%	Total
1st	160	57.1	68	24.3	44	15.7	8	2.9	0	0	280
2nd	96	34.3	63	22.5	78	27.9	32	11.4	11	3.9	280
5th	83	41.5	67	33.5	42	21.0	8	4.0	0	4.6	240
6th	52	21.7	76	31.7	86	35.8	15	6.3	11	4.6	240
8th	90	40.9	75	34.1	45	20.5	10	4.6	0	0	220
9th	97	37.3	97	37.3	55	21.2	9	3.5	2	0.8	260
10th	102	39.2	84	32.2	61	23.5	13	5.0	0	0	260
11th	81	33.8	92	38.3	49	20.4	14	5.8	4	1.7	240
12th	129	28.0	198	43.0	89	19.3	20	4.4	24	5.2	460
14th	55	25.0	120	54.5	36	16.4	7	3.2	2	0.9	220

On nasturtium: The second generation on nasturtium (after origin on kale) gave highest selections for kale and second highest for nasturtium (Table 3, Fig. 4). For over eight generations, selections decreased for kale (from 43 percent to 17 percent) and increased for nasturtium (from 16 percent to 40 percent). Selections for *Isomeris* and mustard did not change appreciatively.

On Isomeris: The second generation on *Isomeris* (after origin on kale) gave highest selections on kale (33 percent), second highest on nasturtium (30 percent) and third highest on mustard (25 percent) [Table 4, Fig. 5]. By the sixth generation, there had been an increase in selections for *Isomeris* (from 9 percent to 22 percent), a decrease for kale (from 33 percent to 17 percent), a slight increase for mustard (25 percent to 32 percent) and only an enatic change for nasturtium.

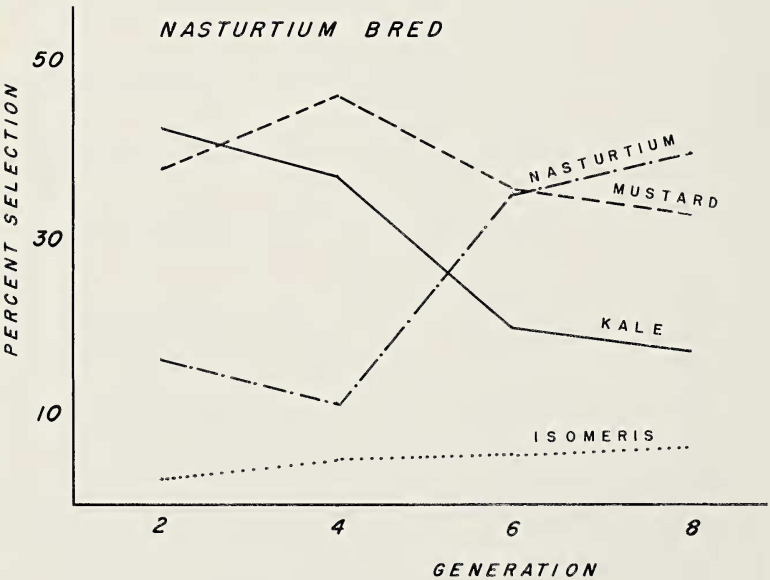

Fig. 4. Food plant selections by larvae of *P. rapae* fed nasturtium.

Table 3. Food plant selections by larvae of Pieris rapae fed garden nasturtium (Tropaeolum majus)

Generation	Mustard		Kale		Nasturtium		Isomeris		None		
	N	%	N	%	N	%	N	%	N	%	Total
2nd	53	37.9	60	42.9	23	16.4	4	2.90	0	0	140
4th	111	46.3	90	37.5	27	11.3	12	5.0	0	0	240
6th	94	36.2	52	20.0	93	35.8	15	5.8	6	2.3	260
8th	133	33.3	69	17.3	161	40.2	26	6.5	11	2.7	400

Table 4. Food plant selections by larvae of Pieris rapae raised on Isomeris arborea

Generation	Mustard		Kale		Nasturtium		Isomeris		None		
	N	%	N	%	N	%	N	%	N	%	Total
2nd	60	25.0	78	32.5	72	30.0	21	8.8	9	3.8	240
4th	74	28.5	88	33.8	44	16.9	43	16.5	11	4.2	250
6th	77	32.1	41	17.1	59	24.6	52	21.7	11	4.6	240

DISCUSSION

The results of these experiments indicate that food plant selections by a phytophagous insect are inherited and that they may be altered first in one direction by change of food plant and then in the other direction.

It is apparent too that food plants which are not normally desirable (such as *Isomeris*) can become at least a potential food plant, even if not greatly desired.

It seems likely that in a genetic sense, these strains never become homozyzous, or pure, strains. This is shown by the fact that a strain which by selection has been developed for a preference toward kale can be reversed to a preference toward nasturtium. It seems highly possible that chromosomal genes are not involved in the type of selection being considered here, but there is no answer to the question of what the mechanism of the inheritance is. Change in selection of plants during the course of a single generation as shown in a previous paper (Hovanitz and Chang 1963) is another point that must be brought into consideration as regards the mechanism of this effect.

The genes obviously do not change, only the physiology and chemistry of the cells in the individual. This "transference of induced food habit" (Sladden, 1934) is a biological principle

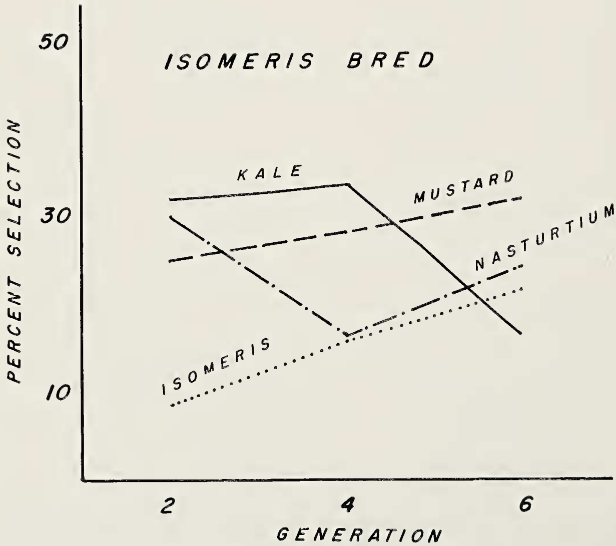

Fig. 5. Food plant selections by larvae of *P. rapae* fed Isomeris.

which is as yet not understood, either within the single generation or between successive generations. Simple inheritance may not be involved.

SUMMARY

Four strains of *Pieris rapae* have been altered in their food plant preferences by "induction". By this is meant that the largae have been induced to prefer a particular plant. The results indicate that if a larva is induced to prefer a particular plant, it's "transduced" adult also prefers that plant for oviposition; this transduction is passed on to the next generation and to all subsequent generations until the trait is again induced to change.

The four strains used in these experiments were fed on mustard, kale, nasturtium and *Isomeris*. Each of these strains gained a preference of the food plant on which it was fed, or at least gained a greater preference for it than it had before the induced effect.

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